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INDEX NUMBERS AND SCORING OF WATER SUPPLIES—PART II[1]

By Abel Wolman[2]

In a previous discussion[3] the author presented certain experience data with reference to the 20°C. and 37°C. bacterial contents of filtered chlorinated tap waters, which were to serve as the bases for future studies of similar waters. In this earlier paper it was not possible to develop similar material for B. coli determinations, since the results were not in such form as to be classified by daily values. Since that time, however, the frequency distributions of a large number of B. coli tests have been studied and it was thought desirable to make them available for publication. In this instance, as in the case of the earlier data on total bacterial contents, the material is designed to serve as the basis or guide-post for future comparisons with filtered chlorinated waters.

1. Analysis of observation. As far as the author is aware no attempt has been made hitherto to study the distribution of *daily* B. coli contents in a water supply. The current methods in use for the quantitative interpretation of B. coli tests have made it difficult to obtain values for any but rather long series of results, which fact prevented in general the analysis of observations excepting in mass, as by months or years. In this discussion, use has been made of the McCrady[4] method of the numerical interpretation of fermentation tube results in order to consider the B. coli numerical values for each day during a period of three years. A brief description of the procedure of analyzing the daily results will make clear the advantage in this system of classification.

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[1] Presented before the Chemical and Bacteriological Section at the Montreal Convention, June 24, 1920. Discussion is requested and should be sent to the Editor.

[2] Division Engineer, Maryland State Board of Health, Baltimore.

[3] Journal, September, 1919, page 444.

[4] McCrady, M. H., The Numerical Interpretation of Fermentation-Tube Results, Journal of Infectious Diseases, Vol. 17, No. 1, July, 1915.

Wolman, Abel and Weaver, H. L., A Modification of the McCrady Method of the Numerical Interpretation of Fermentation-Tube Results, Journal of Infectious Diseases, Vol. 21, No. 3, Sept. 1917.

McCrady, M. H., Tables for Rapid Interpretation of Fermentation-Tube Results, The Public Health Journal (Canada), Vol. 9, No. 5, May, 1918.

For our present purposes, the B. coli tests in the tap water of a city of Maryland for the years 1917, 1918, and 1919 were chosen. On each day during this period, B. coli determinations were made by incubating six tubes in each of the three dilutions of 10, 1, and 0.1 cc. Lactose broth was used for primary fermentation, plates were made upon Endo medium, with secondary fermentation tests in lactose broth, in accordance with "Standard Methods." From the results in the six tests in each of the three dilutions noted, a numerical value for B. coli content was obtained. The B. coli values thus recorded correspond to what is known as the "completed" B. coli

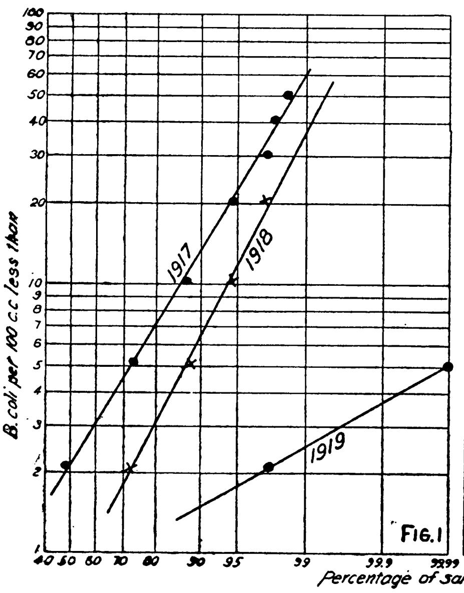

FIG. 1

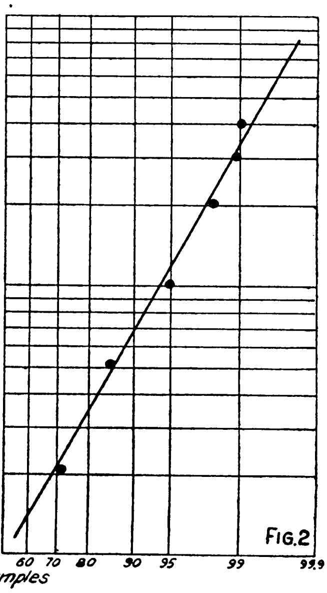

FIG. 2

FIG. 1. FREQUENCY-DISTRIBUTION RECORDS OF B. COLI IN FILTERED AND CHLORINATED WATER

FIG. 2. SUGGESTED MAXIMUM FREQUENCY-DISTRIBUTION LIMITS OF B. COLI IN FILTERED AND CHLORINATED WATER

test.[5] The observations have been grouped then as shown in table 1 and in figure 1. In developing the curves in figure 1 a total of 652 B. coli tests have been used, representing an aggregate of 11,736 initial fermentation tests, all of which naturally have been used in the final evaluation of the data.

It is interesting to note that the values group themselves (fig. 1) according to a definite law. Attention is called to the nature of the distribution of the B. coli results, since this distribution, which is similar to that of the total counts, was not sufficiently emphasized in the author's previous communication.[6] In the case of the bacterial values with which we are concerned, as in many other biological problems, the logarithms of the B. coli contents rather than the bacterial densities themselves are distributed in accordance with the Gaussian or normal law of error. The significance of this distribution in determining accurate methods for the more complete analysis of such phenomena has been emphasized by other investigators,[7, 8] but, in the present problem, these more academic considerations need not concern us.

2. Significance of findings. In order to make the data in table 1 of value as characteristic of "normal" filtered chlorinated tap waters, it is necessary to correct the material by eliminating therefrom all samples which were obtained during abnormal operating periods, such as in intervals of chemical shortage and closing of filtration plant, with use of improperly treated water from temporary sources. Such a correction has been made and the resulting figures are shown in table 2 and in figure 2.

In the light of the United States Treasury Department requirements for water to be used on interstate carriers, it is interesting to examine the data shown on the "standard quality sheet" (figure 2).

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[5] Standard Methods of Water Analysis, American Public Health Association, 1917.

[6] Wolman, Abel, Index Numbers and Scoring of Water Supplies, JOURNAL, September, 1919.

[7] Michael, Ellis L., Concerning Application of the Probable Error in Cases of Extremely Asymmetrical Frequency Curves, Science, N. S., Vol. 51, No. 1308, Jan. 23, 1920.

[8] McEwen, George F. and Michael, Ellis L., The Functional Relation of One Variable to Each of a Number of Correlated Variables Determined by a Method of Successive Approximation to Group Averages: A Contribution to Statistical Methods, Proc. American Academy of Arts and Sciences, Vol. 55, No. 2, December, 1919.

The Treasury Department standard has reference to individual samples and gives no indication, for example, of what deviation from the 2 per 100 cc. requirement during a year would be allowable. Such material as here presented offers some means of determining what variation in colon content may be expected in normal operation from day to day. It is the author's opinion, from his familiarity with the material here set forth, that the curve in figure 2 should represent the *maximum* permissible deviations from the "2 B. coli per 100 cc." standard for filtered chlorinated waters, since the observations include several years of plant operation of lower efficiency than it has attained since and which it is assumed it should continue to surpass.

TABLE 1

Variation of B. coli content of tap water

YEAR	TOTAL SAMPLES	TOTAL TUBES	B. COLI PER 100 CC. BETWEEN								
			0–2	3–5	6–10	11–20	21–30	31–40	41–50	51–100	101+
1917	267	4806	132	63	39	19	7	1	1	3	2
			49.4	73.1	87.6	94.7	97.4	97.8	98.2	99.3	100.0
1918	202	3636	146	32	13	5	0	2	0	2	2
			72.3	88.1	94.5	97.1	97.1	98.0	98.0	99.0	100.0
1919	183	3294	178	5							
			97.3	100.0							

TABLE 2

Variation of B. coli content of tap water; corrected values for use in standard quality sheet

YEARS	TOTAL SAMPLES	TOTAL TUBES	B. COLI PER 100 CC. BETWEEN								
			0-2	3-5	6-10	11-20	21-30	31-40	41-50	51-100	101+
1917, '18, '19	614	11,052	441	94	47	20	5	2	0	3	2
			71.9	85.5	95.0	98.0	98.8	99.0	99.0		

NOTE: Upper figures in tables 1 and 2 represent number of samples in each class, lower figures the cumulative percentages of the total number of samples.